OPERATIONS

ANGLE LIMITATIONS

In movies, we see various helicopters performing such air show maneuvers as full rolls and Immelmann turns. This may seem surprising, considering that flight restrictions imposed on most helicopters limit the allowable bank and sideslip angles.

Listed in the operator's manual, these restrictions are there to ensure flight safety, structural integrity, and generally to keep the pilot out of some potentially dangerous conditions.

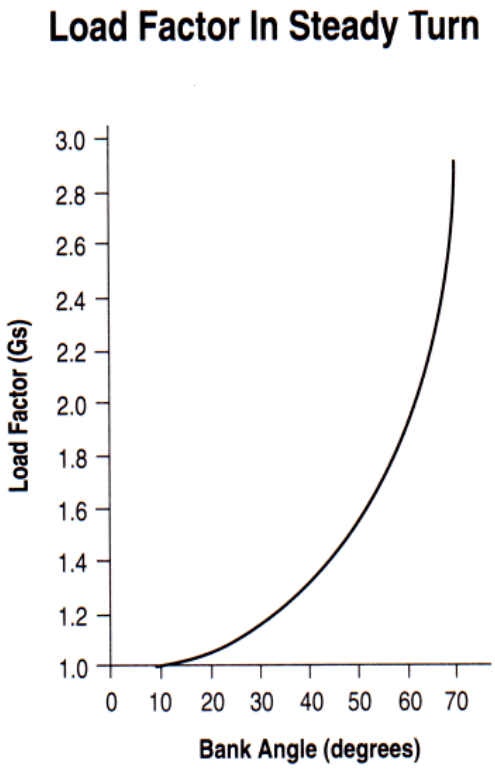
Bank angle

The bank angle restriction warns the pilot that while his helicopter may have the control capability to roll steeply, it has only enough power and/or thrust capability to maintain a turn up to a certain limit of tightness. A number of helicopter (and airplane) accidents have been attributed to losing altitude while trying to exceed this limit too close to the ground.

The load factor in a turn is related to the bank angle as is shown. For instance, a bank angle of 60 degrees corresponds to a load factor of 2.

To hold this bank angle in a turn, the rotor has to develop twice as much thrust as in straight and level flight. For the helicopter not to lose altitude or speed during the maneuver, the engine must have enough reserve power to satisfy the requirements of this suddenly doubled effective weight. Very few helicopters can rise to this challenge.

The result is that the engine limit is reached and the rotor slows down--leading to rotor stall and loss of thrust just when it is needed most. Making use of the kinetic energy of forward flight by slowing down in the turn may supply some of the extra power required.

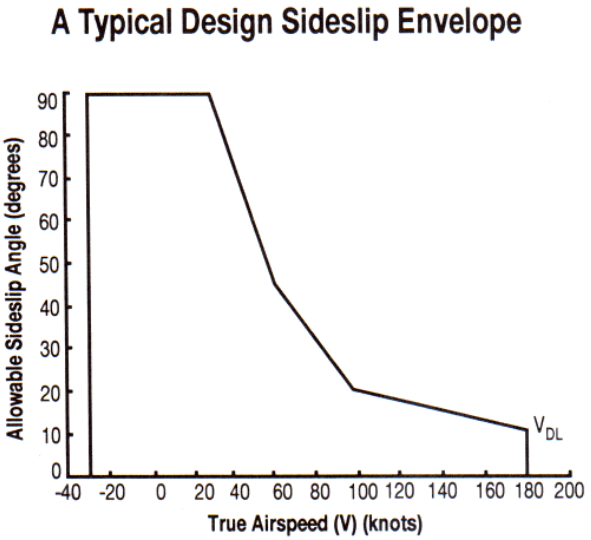


Calculations for a typical helicopter indicate that slowing down from 115 knots to 100 knots while going half way around a 2-G turn can increase the available power by an increment equal to about 70% of that required to fly level--but that still might not be enough.

Similarly, some potential energy can be converted into power by losing altitude (if there is altitude that can be lost). Calculations for the same typical helicopter show that a loss of 100 feet during the 180^{o} turn at 2 Gs could provide an effective boost of power equal to about 50% of the level-flight power.

Sideslip angles

Many helicopter pilot's manuals contain allowable sideslip envelopes such as that shown below.



The sideslip angle is restricted at high speed to avoid excessive loads on the tail boom and excessive flapping of the tail rotor. Another concern is the suction loads on side windows that could suck them out of their frames.

The limits were set after the helicopter's builder studied the results of his "flight-strain survey." This survey involves using a prototype with a full set of instrumentation, including strain gauges, flapping sensors, and a sideslip indicator.

The fallacy of presenting the limit in the operator's manual for the production helicopter is that the pilot has no sideslip indicator in the cockpit! And it is perhaps just as well, since a pilot who got himself either deliberately or inadvertently into a maneuver that involved high sideslip angles would probably not have time to look at the indicator anyway.

The possibility of overstressing the helicopter, however, does exist. The air-to-air trials at the Navy's Patuxent River flight test facility resulted in at least one tail boom suffering some permanent damage. And I know of at least one case where excessive tail-rotor flapping due to a high sideslip angle at high speed led to a fatal crash.

The designer's challenge is to make sure that their helicopters can stand up to whatever a pilot might do to them. One of my test-pilot friends wants to be able to spin completely around during a dogfight to bring his guns to bear on someone chasing him.

Pitch angles

There are usually no restrictions on pitch angles. Pulling the nose up during a quick stop might interfere with the field-of-view, but it does not require extra power or put excessive loads into any components. A nose-down attitude is used to accelerate, but the pilot can prevent the helicopter from losing altitude during this maneuver even if the power limit is reached by simply backing off. Thus it is left up to the pilot as to how much pitch attitude change he can tolerate.

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